Gravitational Lensing with SNAP

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Two Unknown Cosmic Constituents

Spatial flatness revealed by recent microwave background results indicates *two* unknown components of cosmic energy:

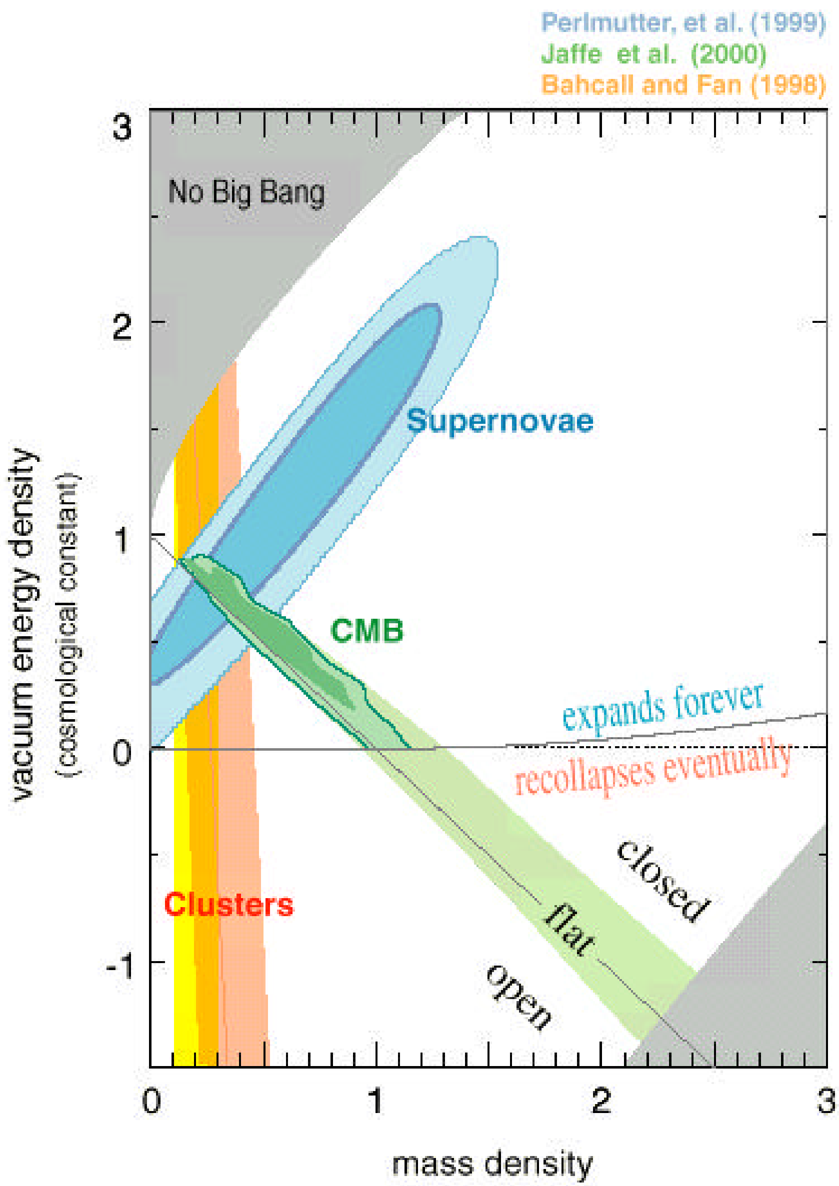
- **Vacuum energy**

  (L term or variant)

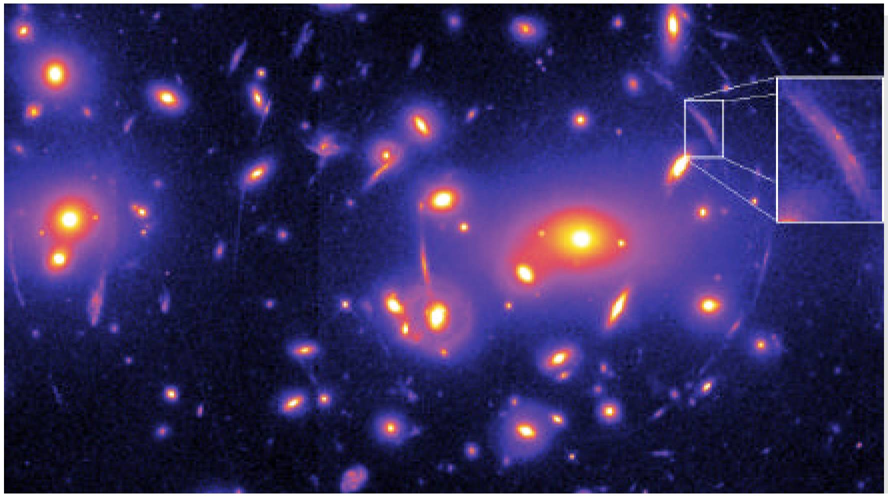
- **Gravitating dark matter**

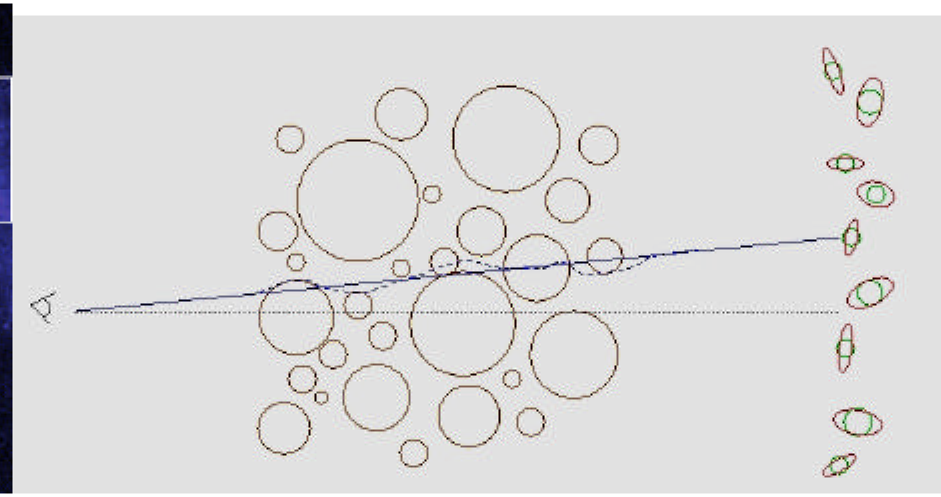
  (non - baryonic)

We need to physically understand BOTH components



Scientific Promise of Gravitational Lensing





- **Distribution of dark matter on various scales – unique probe**

- **Constraints on W, L, *w*…complementing and breaking degeneracies present in other methods (SNe, CMB)**

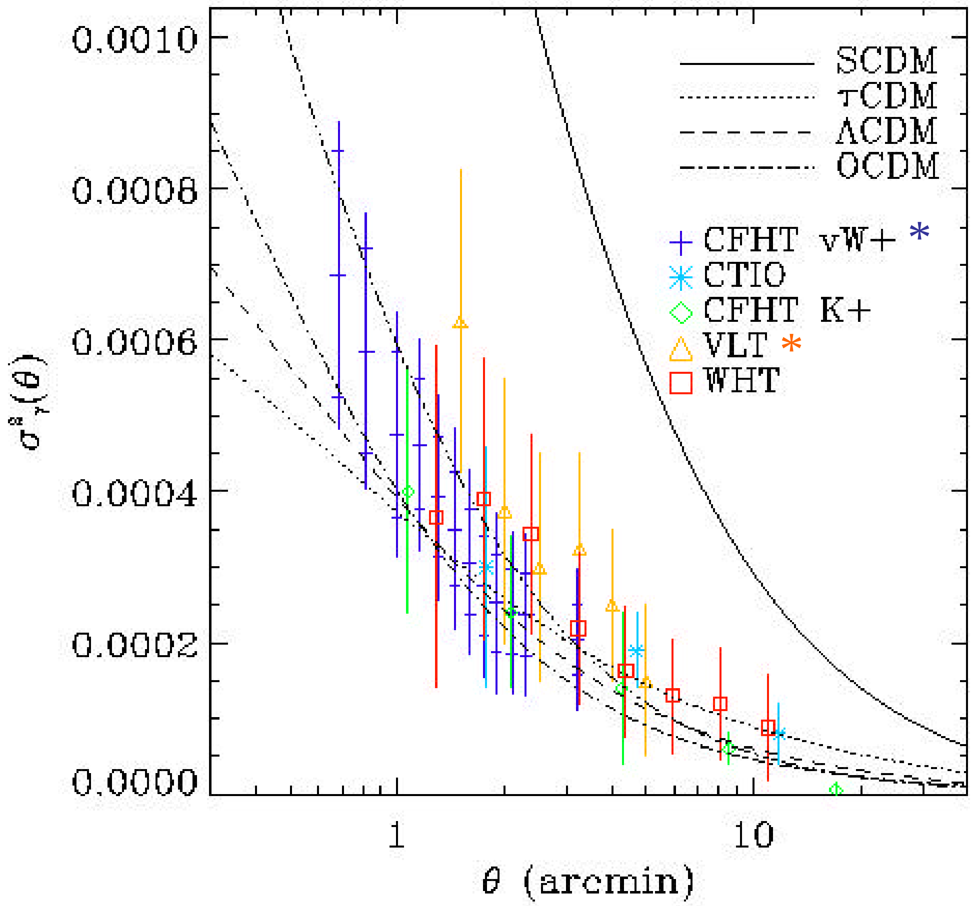
- **Verification of gravitational instability via direct evolutionary tests**

- **Masses of galactic halos by morphology, epoch & environment (via `galaxy-galaxy’ lensing)**

`Cosmic Shear' from Large-scale Structure

Shear variance

1% RMS ellipticity



angular scale

* stat. Errors (inner error bars) + cosmic variance (full error bars)
* cosmic variance not included
[All other plots include cosmic variance]

® *ground-based data yields only weak constraints on cosmological models*

The Limitations of Weak Lensing Programs

Recent detailed study

Bacon et al (astro-ph/0007023)

Noise:

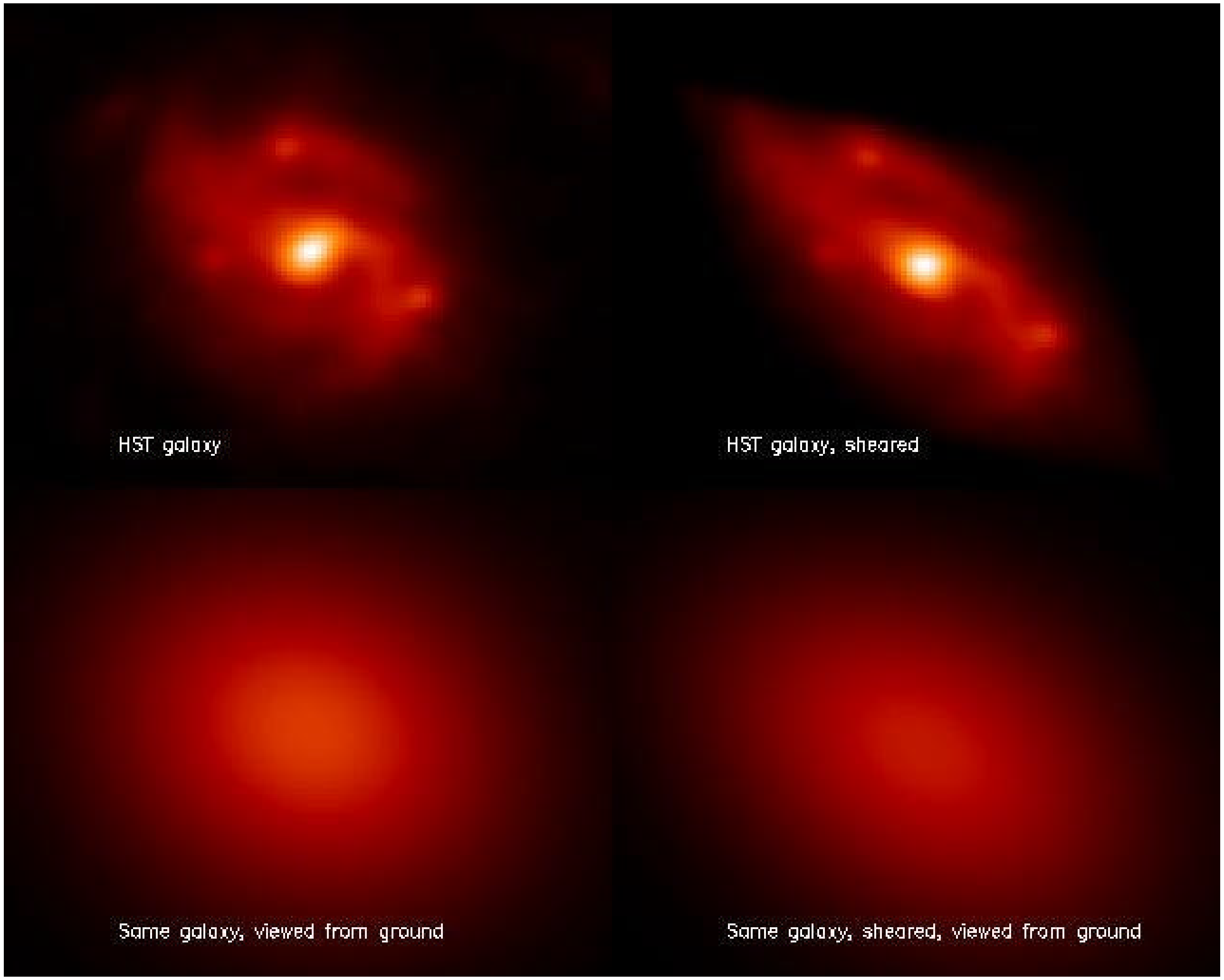
- **Seeing – induced noise dominates signal if s > 0.8 arcsec**
- **Statistical – arising from surface density/field/depth**

Systematics:

- **psf anisotropies – e.g. tracking (smear) 10% ® < 0.5% rms**
- **instrumental shear – e.g. optical aberrations » 0.3% rms**
- **redshift distributions (foreground & background) Dz » ±0.2**
- **biases in algorithms <0.5% rms**

only adjustable variable for ground-based programs

The Way Forward: Space



Not just better images :

less reliance on PSF + enhanced surface density of resolved galaxies

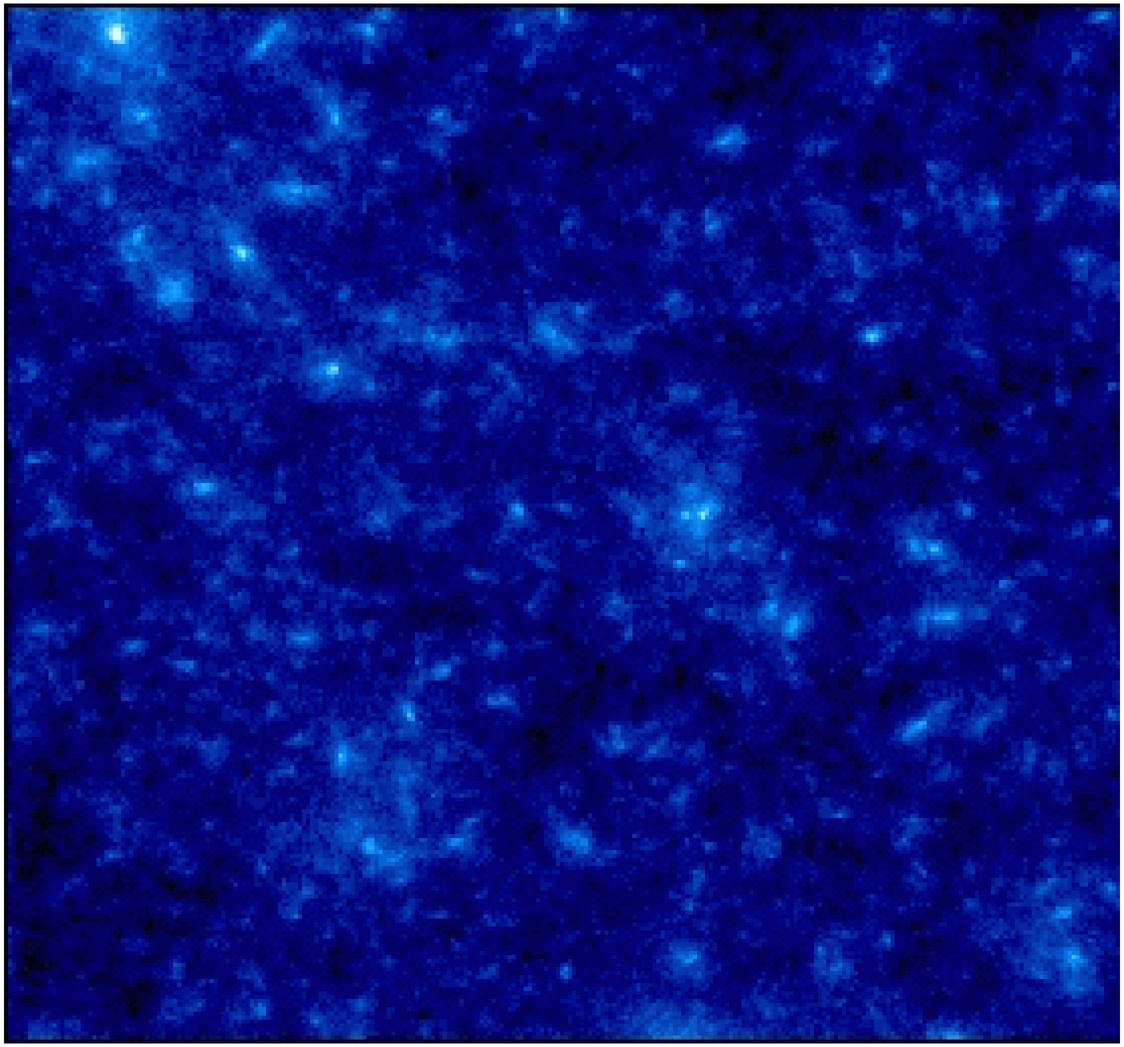
What can SNAP achieve?

Superior image quality & survey depth
SNR µ $n^{0.5}$ $z^{0.7}$ s^{-1} ® x 5-10 improvement
(before considering reduced systematics)

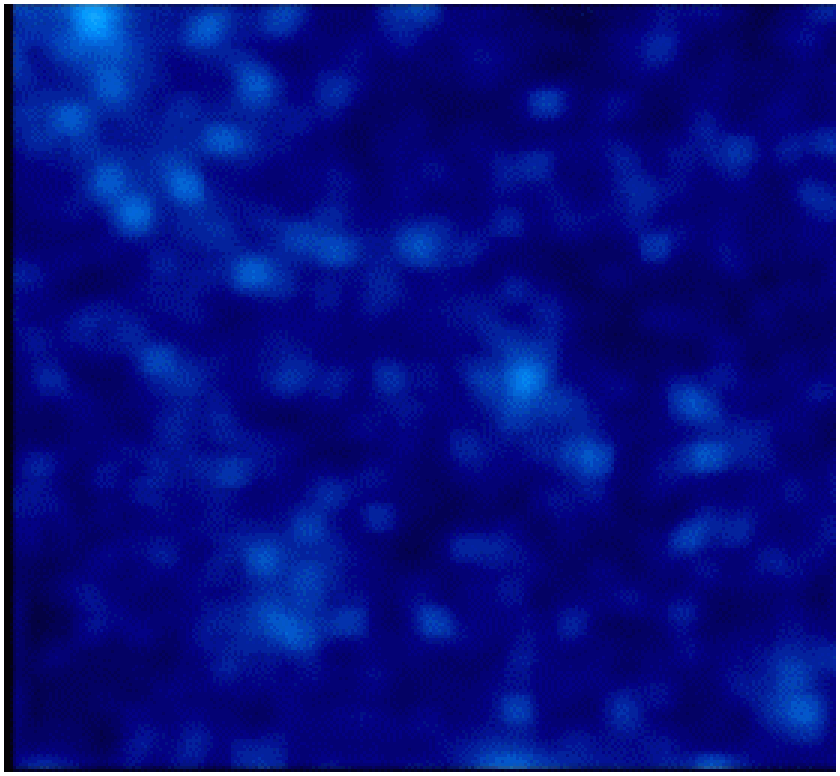
- **High precision measurements of power spectrum and cosmological parameters:** Ω_m, Λ, s_8, etc **complements SNe and other methods**
- **Maps of the DM distribution: mass limited cluster catalogs, DM in filaments and voids**
- **Evolution of large-scale structure: direct tests of gravitational instability via redshift-dependences**
- **Galaxy-galaxy lensing: galactic mass as function (z,type, environs)**

Mapping the Dark Matter

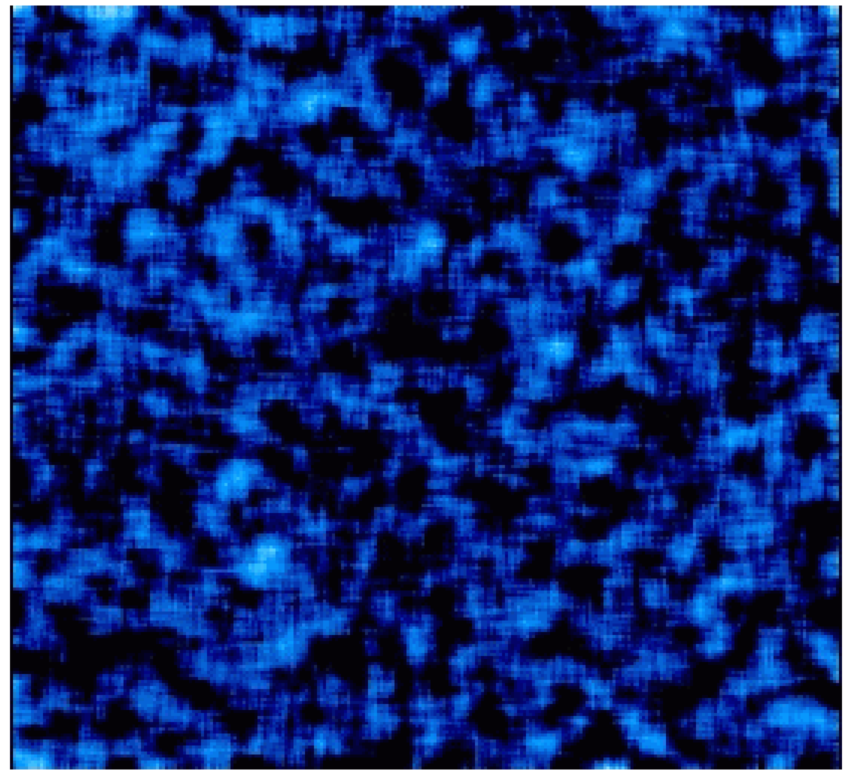
0.5^{o} x 0.5^{o} simulation (ΛCDM, Jain et al)



Recovering the mass distribution with typical ground-based data

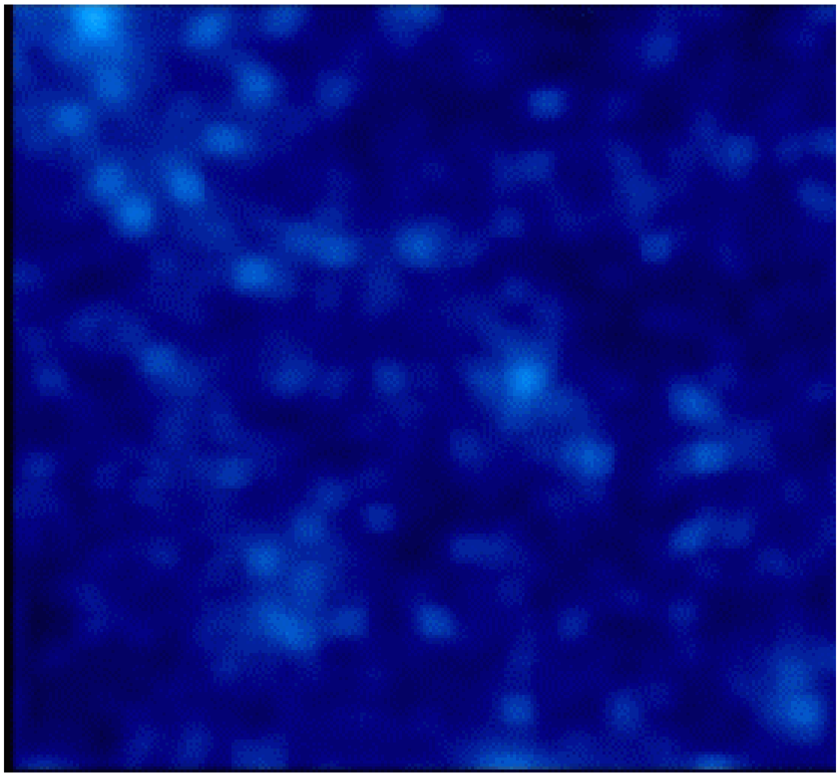


ΛCDM: 1 arcmin smoothed



4-m telescope survey

Recovering the mass distribution with SNAP



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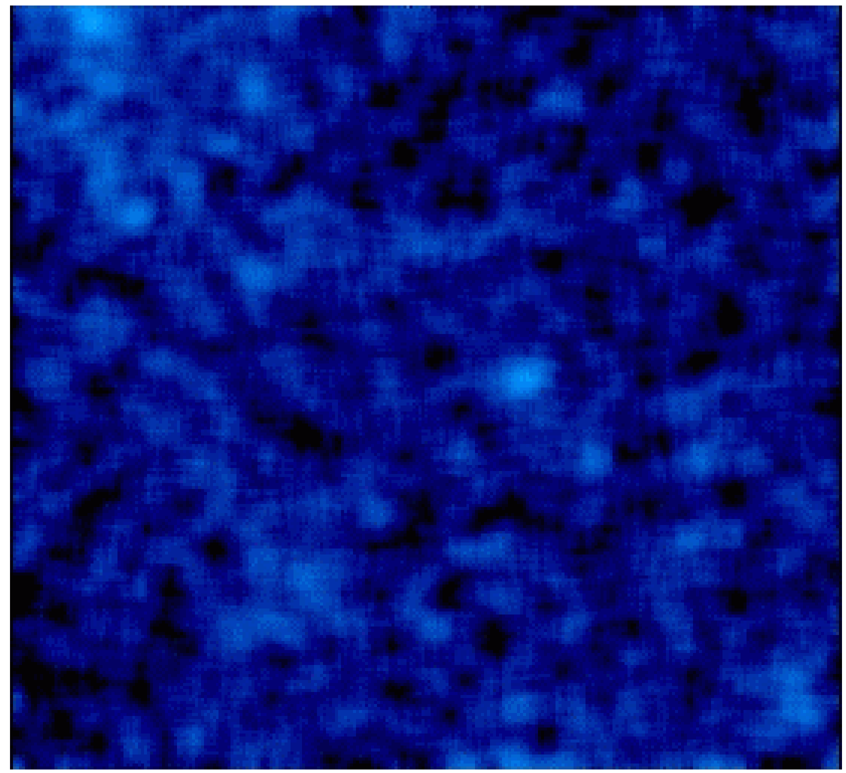
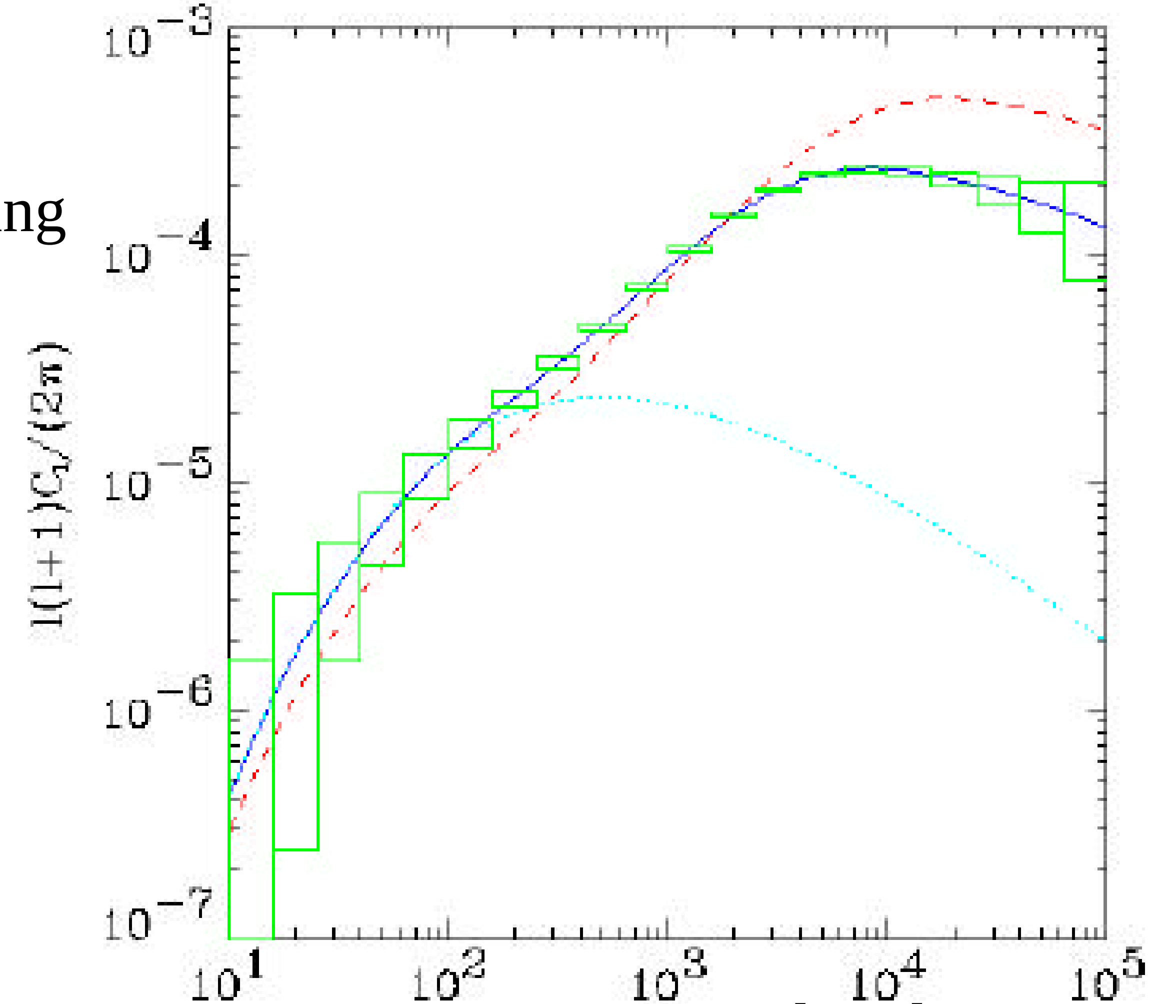


SNAP survey

Lensing Power Spectrum

Clustering power



large angle

l multipole

small angle

OCDM

ΛCDM

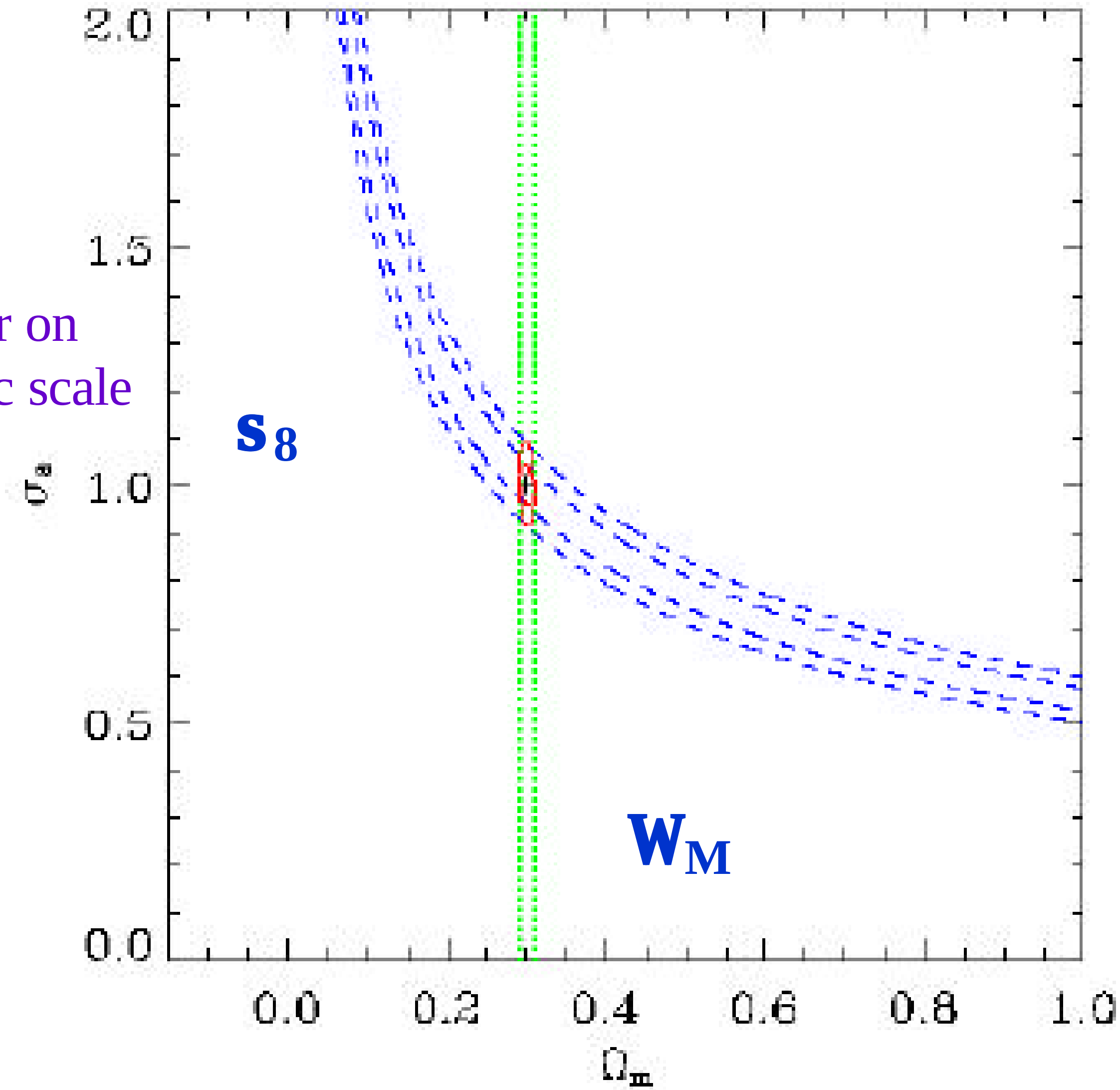
probing non-linear physics

ΛCDM (linear)

SNAP WF survey [300 deg^2 ; 100 g arcmin^{-2}; HST image quality]

New cosmological constraints

Power on
8 Mpc scale



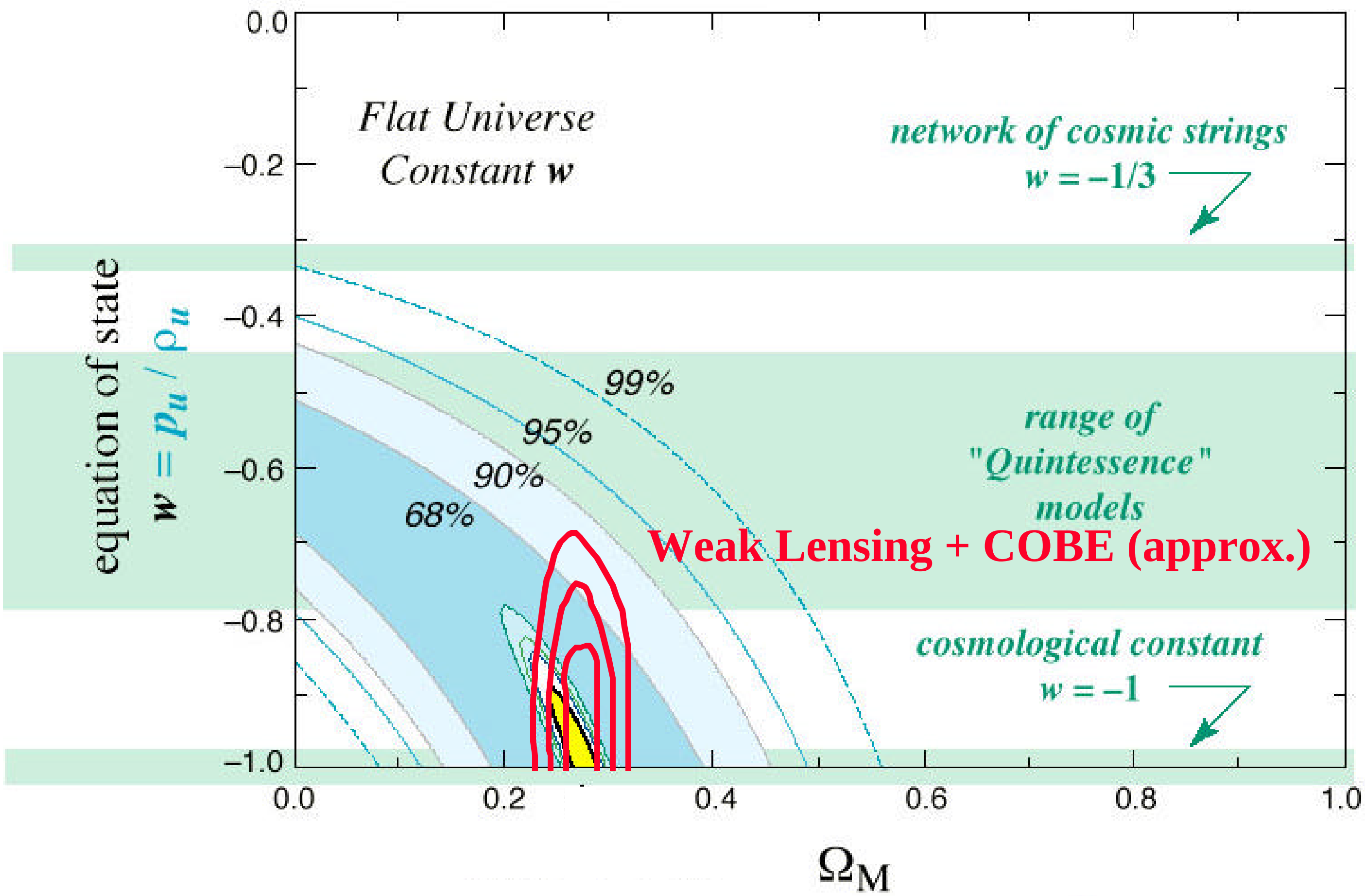
Variance: $\langle k^2 \rangle$

Skewness: $\langle k^3 \rangle$

Data will break current degeneracies (e.g. W_M and s_8 ; W_M and w)

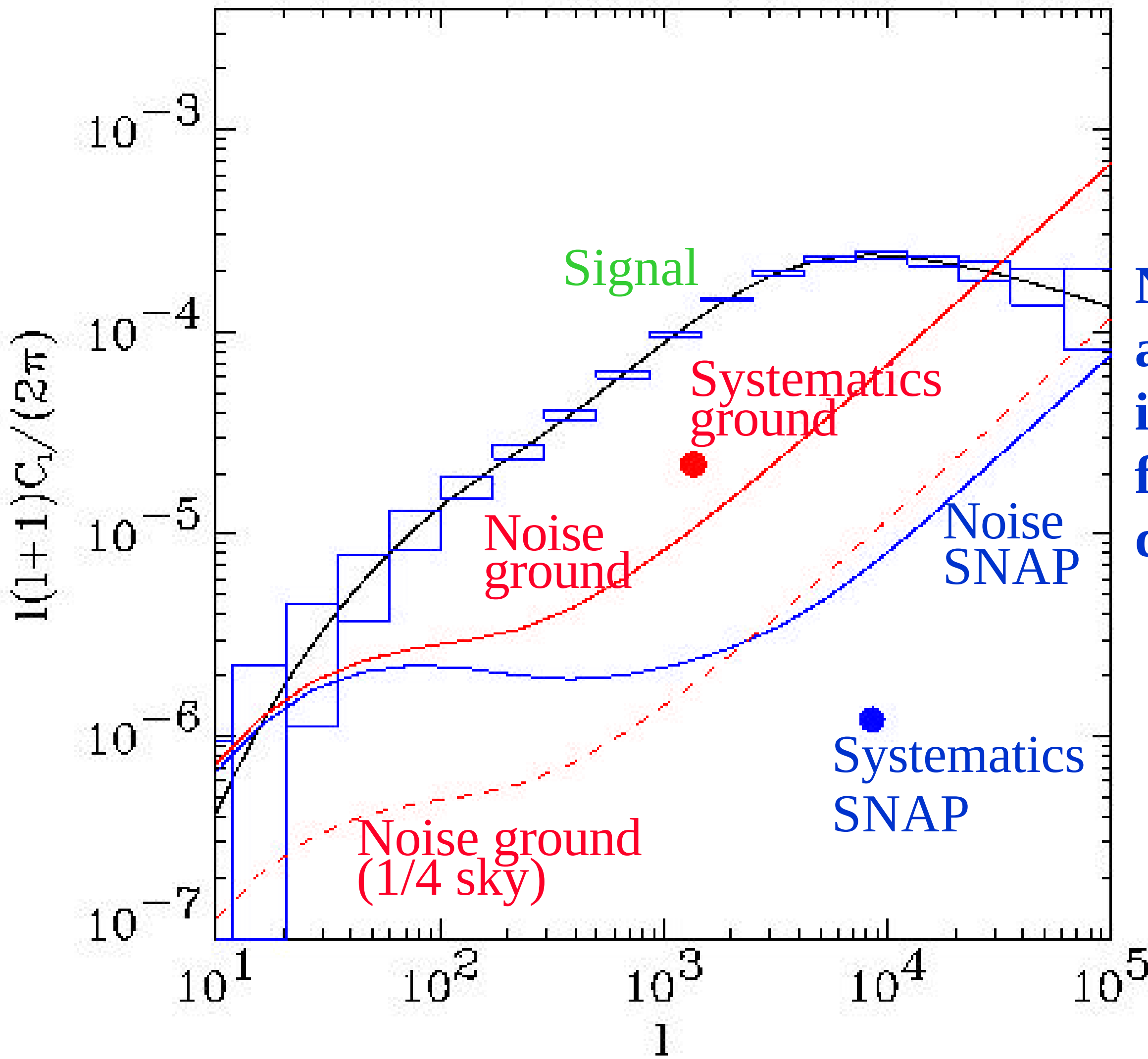
Complementarity of Weak Lensing & Supernovae

Weak Lensing constrains *W* with little dependence on w



→ Allows study of evolution of w with SNe

Ground vs Space



Noise and systematics are both greatly reduced in space as demonstrated from HST & ground-based data.

Unrivalled Strengths of SNAP for Weak Lensing Studies

- **Wide field in space -** **large survey area with exquisite image quality**
- **Stringent optical requirements and small psf -** **greatly reduced systematics**
- **Depth of survey -** **unsurpassed statistics and mapping resolution**
- **Many photometric bands -** **evolution of structure as function of redshift**
- **Multiple exposures -** **control of systematics**

$\longrightarrow$ Precision cosmology and maps of the Dark Matter